1 Motivation for this Experiment

1.1 The Electric Form Factor of the Neutron

Measuring the electric and magnetic form factors of the nucleon is of tremendous interest in the nuclear physics community since these quantities can provide important information to our understanding of the nucleon structure and can be directly compared to many QCD based calculations.

The proton form factors have been measured very precisely over a wide range of kinematics via electron scattering (see e.g. [1, 2]). The magnetic form factor of the proton can be obtained from the elastic ep scattering cross sections and, recently, its electric form factor has been measured precisely over a large Q^2 range using the recoil polarization technique [3]. Our knowledge of the proton electromagnetic form factors is at a few percent level for Q^2 values up to about 3 $(\text{GeV/c})^2$.

The situation changes in case of the neutron. The neutron magnetic form factor was measured accurately in the low and intermediate Q^2 region ($Q^2 \leq 1$ $(\text{GeV/c})^2$) [4, 5]. Here inclusive scattering off polarized ^{3}He and the ratio of cross sections for the $D(e, e'n)p$ and $D(e, e'p)n$ has been used. The neutron electric form factor G_E^n, however, remains less well known. Two technical difficulties are hampering a precision measurement of G_E^n. Firstly, a free neutron target does not exist in nature, one has to use nuclear targets such as deuteron or helium-3 and rely on theoretical calculations to extract the neutron information. Secondly, G_E^n is extremely small. Nevertheless, the neutron electric form factor is of special interest, because the neutron has zero charge, a non-zero form factor has to come from a nonuniform spatial distribution of valence or sea quarks.

1.2 Measurements and Extractions

With the recent development in both few-body nuclear theories, as well as in experimental techniques including polarized beam and polarized targets, G_E^n has been or is being measured in several laboratories around the world. These measurements can be divided into two categories based on the target used: *i)* G_E^n extracted from the $D(\vec{e}, e'\vec{n})/\vec{D}(\vec{e}, e'n)$ reactions [6, 7, 8, 9, 10] and *ii)* G_E^n extracted from the $^3\vec{H}e(\vec{e}, e'n)$ reaction [11, 12, 13, 14]. Because nuclear effects are present in both ^{2}H and ^{3}He targets, these two methods of measurements are complementary and can cross check each other. A recent exact Faddeev calculation from Golak *et al.*[15] on the extraction of G_E^n using ^{3}He emphasizes that semi-exclusive asymmetry measurements are very well suited for low values of Q^2 (≤ 0.5 $(\text{GeV/c})^2$), making a low Q^2 ^{3}He experiment interesting and timely.